Lightweight 2 kW Diesel-Powered, Electric Generator

Tri-Service Power Expo

July 16, 2003
Norfolk, VA

Presented by Greg Cole

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Problem Statement

- Post-Cold War military strategies include emphasis on lighter, more mobile, and more easily deployable armed forces
- Standard DoD electrical generators are heavy
- A lighter, more compact power source would benefit all branches of the armed services

Specific Need

- Marine Corps System Command requires a man-portable power source to operate electronics and communications equipment for the Team Portable Collection System (TPCS)
- Power is expected to exceed 1 kW @ 28 VDC
- Desired weight is less than 50 lbs
- Desired fuel is diesel

Baseline Technology

Image from http://www.pmmep.org/technicaldata/2kw.htm

- The DoD's lightest, diesel-powered generator is the MTG
- Model MEP-501A
  - 2 kW @ 28 VDC
  - 138 lbs
- Model MEP-531A
  - 2 kW @ 120 VAC / 60 Hz
  - 158 lbs
- MTGs are extremely heavy because a COTS engine is coupled with a COTS alternator

Solution

- Mainstream's lightweight generator is designed as an integrated unit and each component is optimized to reduce weight.
- Weight reduction is primarily a result of:
  - an engine block fabricated with advanced engineering materials
  - integration of a permanent magnet alternator into the engine flywheel

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Materials Comparison

	Standard MTG Engine Material	Mainstream's Engine Material
Density	0.099 lb/in3	0.066 lb/in3
Yield Strength	22 ksi	21 ksi
Ultimate Strength	45 ksi	40 ksi
Hardness (500 kg load, 10 mm ball)	75	70

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Mainstream Engine

- Only U.S. built diesel-engine in this size range
- 4 generations of engines

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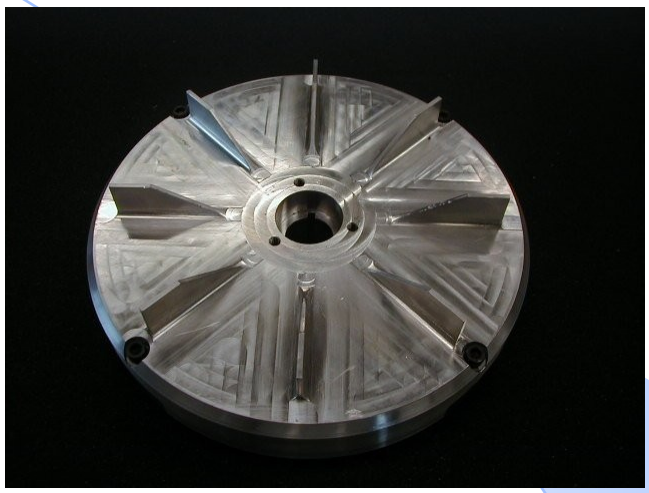
Engine Features

- Shaft Power: 2.8 kW
- Cycle: 4-stroke, naturally-aspirated, compression-ignition, single-cylinder
- Cooling: air-cooled
- Starter: manual recoil

Integrated Alternator

- Permanent magnets generate AC power that is rectified into DC power
- Flywheel provides inertia required for reciprocating engine
- Fan cools engine and alternator



Generator Size and Weight

- Unmounted Generator
  - 14” (L) x 11” (W) x 16” (H)
  - 48 lbs

- Backpack Generator
  - 18” (L) x 17” (W) x 20” (H)
  - 65 lbs

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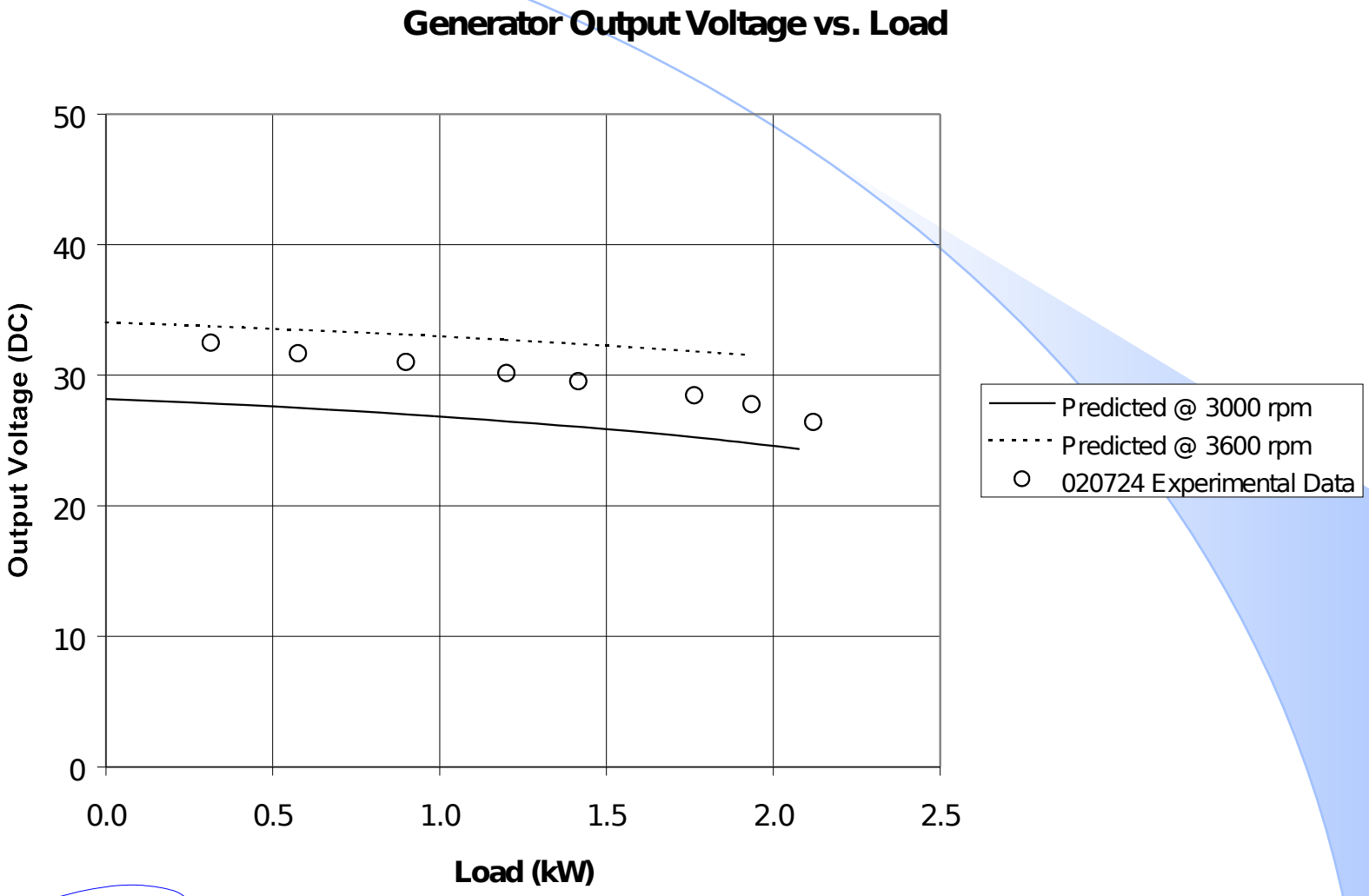
Generator Power: 2 kW @ 20-32 VDC



Governor maintains nominal engine speed

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Fuel Specification

- Fuel Consumption: 0.23 gal/hr at full load
- Fuel Types
  - Diesel
  - JP-5, JP-8, kerosene
- Fuel Source
  - Line feed from tank or Jerry can
  - Optional on-board fuel tank available

Fuel Test Results

FUEL	GENERATOR CAPACITY	FUEL CONSUMPTION
DIESEL	2.0 kW	0.22 gal/hr
JP5	2.0 kW	0.23 gal/hr
JP8	2.0 kW	0.27 gal/hr
KEROSENE	2.0 kW	0.24 gal/hr

Generator Noise

- Baseline 2 kW MTG
  - 79 dBA at 25 ft
- Mainstream 2 kW
  - 68 dBA at 25 ft

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Generator Features

- Instrumentation
  - Voltmeter
  - Ammeter
  - Hour meter
- Power Receptacle
  - MS3450W32-17S
  - per MIL-C-5015G
- Circuit Load Protection
- Ground Terminal

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Operating Environment

- Temperature
  - Operating: -25°F to 125°F
  - Storage: -40°F to 158°F
- Altitude
  - Operating: 10,000 feet
  - Storage: 40,000 feet
- Angle of Inclination
  - 20° maximum

Comparison to Baseline

Standard DoD MTG	Mainstream Generator
2 kW @ 28 VDC	2 kW @ 28 VDC
138 lbs	**65 lbs**
30”(L) x 16”(W) x 22”(H)	18”(L) x 17”(W) x 20”(H)
skid-mounted	backpack mounted
4-man transport	1-man transport
79 dBA	68 dBA

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Frame Impact Test Results

- Initial frame was modified A.L.I.C.E. backpack.
  - 740.3C Drop Test (Ends)
    - Passed six drops each from front, left, and right.
    - Bent during first five drops on back.
    - Cracked on sixth drop on back.
  - 740.2 Drop Test (Free Fall)
    - not performed

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Frame Impact Test Results

- Second frame
  - enclosed generator
  - thicker frame
  - 740.3C Drop Test (Ends)
    - Passed 6 drops each from front, back, left, right
  - 740.2 Drop Test (Free Fall)
    - Passed 6” and 12” test
    - Corners bent at 24” and 36”.
    - Base bent at 44”
- Final frame
  - added cross brace
  - added folded base
  - welded instrument panel increases stiffness

Life Test Results

- Version 1: Phase I generator
  - Prototype #1: 1000 hrs w/o any PM
- Version 2: decreased weight / increased power
  - Prototype #2: 250 hrs without failure
- Version 3: decreased weight
  - Prototype #3: failed after 37 hrs
  - Prototype #4: failed after 48 hrs
- Version 4: improved reliability
  - Prototype #5: 476 hrs without failure (tests continue)
  - Prototype #6: field tested at Ft. Drum (on display)

Field Tests

- Phoenix Warrior Field Exercise
- Ft. Drum, NY
- June 4-20, 2003
- U.S. Army 10th Mountain Division
- U.S. Air Force 20th Air Support Operations Squadron

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Field Test Results

- “Size and weight of the generator is outstanding”
- “Multi-fuel is great”
- “Power output is good”
- “Well built will take the pounding of the field”
- “Site glass on fuel tank good idea”
- “Runs noticeably quieter than the MIPS generator”

Field Test Results (cont.)

- "The sliding throttle should be changed to one that is easier to adjust and allow for more precise adjustments."
  - MEC is currently addressing this need.
- "Slave receptacle would be nice for starting generator set and jump-starting the HMVV"
  - MEC is currently investigating this feature as an option.
- "Voltage at startup is too high and could lead to equipment damage if personnel do not adjust throttle"
  - MCSC requires 32-20 VDC, 20th ASOS requires 30-20 VDC
  - MEC can provide optional voltage regulator

Program Status

- Performance and life testing is complete on four generations of prototypes
- Field testing by 20th ASOS is complete
- Q3FY03-Q4FY03: Final test phase of program
  - continue life tests
  - MCSC field tests
- Q4FY03: Product will be available
- Q1FY04: MCSC plans to begin using generator for TPCS program

Contact Information

- Company Address

  Mainstream Engineering Corp.

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  http://www.mainstream-engr.com

- Points of Contact
  - Technical: Greg Cole, gsc@mainstream-engr.com
  - Contracts: Michael Rizzo, mar@mainstream-engr.com

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Demonstration

- Location: Norfolk Waterside Marriott Parking Lot
- Date: Wednesday, July 16
- Time: 2:45 PM

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